A Practical Method for Production of Foamed Glass

Dr. Aseel B. Al-Zubaidi*

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Abstract

A two stage preparation method of foamed glass is described here aiming to achieve reproducibility and convenience. Fritting of the solid components assembles the first stage; where firing a mix of the frit, foaming agents and the liquid component gather the second stage. Almost uniform cellular structure of the foamed glass is achieved at relatively low firing temperature of the mix (820°C for 10 min). The cellular structure is enclosed with a shell of continuous surface.

Physical properties (density, porosity and water absorption) are measured for the product along with the mechanical properties that concerns production of building blocks, namely impact and compression strength.

The flexibility of the presented two stage preparation method simplifies future attempts to modify its properties to adapt particular applications.

طريقة عملية لتصنيع الزجاج الرغوي

الخلاصة

تم عرض طريقة لتحضير الزجاج الرغوي تتكون من مرحلتين في محاولة لتحقيق شرط تكرارية الانتاج بنفس المواصفات وكذلك لتسهيل عملية التصنيع. يمثل تحويل المكونات الصلبة الى زجاج المرحلة الاولى من التصنيع، بينما تكون المرحلة الثانية هو حرق خليط مسحوق الزجاج مع مساعدات الانتفاخ الرغوي والمكونات السائلة. تم الحصول على تراكيب خلوية منتظمة تقريبا للزجاج الرغوي المصنع في درجة حرارة قليلة نسبيا 820 درجة مئوية لزمن استبقاء 10 دقائق. وتميز التركيب الخلوي بغلاف مستمر مغلق المسامية.

قيست المواصفات الفيزيائية للزجاج الرغوي المصنع مع اهم المواصفات الميكانيكية المطلوبة لهذا النوع من الزجاج ذات العلاقة بتصنيع بلوكات البناء وهي مقاومة الصدمة ومقاومة الانضغاط.

ان مرونة طريقة التحضير من مرحلتين المشروحة في هذا البحث تسهّل المحاولات المستقبلية لتحوير مواصفات الزجاج الرغوي المصنع ليتلائم مع اي تطبيق مقترح.

Introduction

The Foamed glass is a multi-cell non-organic material, characterized by its lightness, inflammability, non-corrosion, insect-biting resistance, aging proof. Unlike foamed polymer (usually polyurethane), the use of the foamed glass has no risk of the emission of harmful fumes. Besides, it doesn’t soften or distort after absorbing moisture or even water. The product can be synthesized in various colors for decoration purposes. Therefore, it is not only the indoor decoration sound absorbing material but can be used in outdoor environments as well.[1]

Foamed glass is mainly used in flat roof construction, where its zero vapor permeability and high

* Materials Engineering Department, University of Technology / Baghdad

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2412-0758/University of Technology-Iraq, Baghdad, Iraq

dimensional stability are important for the long life of the construction. It can be produced in slabs and boards suitable for wall and floor insulation. It is also suitable for insulating underground constructions and green or living roofs. The following figure illustrates some of the foamed glass applications. The major application can be summarized as follows:

1. Used in the designing of sound effect in halls and lecture theater to control the interior echo. Also, it is as a sound effect solution in music halls, theaters, movie theaters, conference halls, as well as the studios for Radio and TV broadcast.[3]
2. Since the sound absorbing cellular glass has outstanding waterproofing and aging resistance, it is especially suitable in the humid environments and open air with windy and/or rainy weather.[4]
3. Used in waiting rooms at airports, bus stations, ports or shopping malls as well as exhibition halls, the flat roofing and walls made with sound absorbing cellular glass can reduce the reverberation and thus increase the clearness of the broadcasting.[5]
4. The sound absorbing cellular glass can be used as silencers too. Compared with fiber sound absorbing materials, the cellular glass doesn't emit fiber dust into the air, thus suitable for the ventilation and air-conditioning which requires clean environment.

Looking at the literature, which is mainly US-patents, it looks that the composition of the foamed glass and foaming agents is the prime concern. When these methodologies are applied at our laboratory, it is found that the results are not reproducible, i.e., the results are not guaranteed due to many floating parameters. These draw the attention that the production of the foamed glass is not merely firing of the best composition at hand. The process parameters provided by powder technology, like particle size of mixed powders and the firing conditions is of key importance.[6]

In this work, a unique composition for the foamed glass is presented; along with a new preparation method which should compensate for reproducibility. A two stage method is illustrated which composed of the preparation of the glass frit, crushing, powder milling and sieving though 50μm sieve as the first stage. The second stage is finding the best combination of the foaming agents and firing temperature. The final product samples are characterized for selective physical and mechanical properties[7].

Experimental work:

The starting material that used to prepare the frit is shown in table 1. Urdhuma flint is sieved by 50μm wire-mesh sieve. The other chemicals are of commercial grade, i.e., the purity ≤ 98%, which totally acceptable in the field of glass preparation.

87The above composition is fired at 1100°C for 30min in High-Alumina stone-ware porcelain crucibles. The glass melt is then quenched in water and collected. The glass lumps then dried, crushed and milled to pass 50µm sieve. The resulting powder frit is labeled as Base Glass.

Several experiments is done with the foaming agents to achieve the best results. The goal wan not merely efficient foaming for the Base Glass, but also a uniform bubble distribution is attempted. The final result is almost regular cellular structure of the foamed glass. The foamed glass has thin skin shell which is a regular experience with the preparation of that kind of glasses [3-7]. Table 2 shows the final foaming components added to the Base Glass to make the final mix.

The carbon and sugar fine powder are both of particle sizes below 10µm as observed by an optical microscope. The practice shows that the glass water (sodium silicate penta hydrate) is responsible for the early pileup of the foamed glass around 200°C, the fine sugar powder contribution starts at around 250°C and the climax boosting the foaming process at around 450°C. The effect of the sugar continues to pass 800°C where the contribution of the fine carbon powder becomes obvious. The firing and holding at 820°C is necessary to obtain fully fired carbons and stabilized, i.e., uniform cellular structure of the foamed glass.

Bulk density, apparent porosity and water absorption measurements were carried out according to ASTM C373-88 [8]. The average of three measured samples is recorded. As well, impact and compression strength is also recorded as average of three samples. High definition photographs is presented to illustrate the cellular structure of the prepared foamed glass and to compare it with a standard product.

Results and discussion:

Table 3 shows the physical properties of the prepared foamed glass, where's, selected mechanical properties is shown in table 4.

As shown in table 3, a low bulk density value is accomplished for the foamed glass which a core target of this research work. The density is very close to that of water; which encourage the applications for both indoor (decoration) and outdoor. The outdoor applications is as mentioned in literature may includes sound insulation, thermal insulation, water vapor and humidity insulation as required by modern construction plans. The porosity value (open and closed pores) and the water absorption (indicates closed pores) confirms a skeleton or cellular structure that encourage all insulation purposes.

The two stage method described here, actually give the chance to tailor and modify the physical properties because it separated the preparation of the powdered glass from the foaming stage.

Impact and compressive strength, as shown in table 4, display good values for cellular structure. That suggest the prepared foamed to be used to construct tiles and sandwich panels, along with road construction applications [1].

The achieved mechanical properties can be explained by that the prepared glass is not merely high-alkaline, low alumina glass as usually shown in the literature, but, the addition of talc increases the silica content and probably makes new complexes in the glass medium that helps improve the mechanical properties.

This discussion can be concluded with an endnote that the foaming temperature 820°C is considerably lower than that reported in some literature (around 950°C) and the holding time 10 min is also much lower than that of 60 min usually reported in literature which gains much of reducing energy consumption.

Figure1 displays the outer face and the inner cut face for sample foamed glass, whereas figure 2 shows typical foamed glass fragment as synthesized compared with typical one shown in the literature.

Conclusion:

The methodology to produce the foamed glass in this research work has the advantages of:

1. A practical two stage method that allows developing the glass compositions and the foaming stage separately.
2. Better mechanical properties that helps to adapt various applications.
3. Lower firing temperature and holding time at the foaming stage.

Suggestion for future work:

The insulation properties, heat, sound and humidity insulation is suggested for future work as highly porous, cellular structure is achieves with the prepared foamed glass

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Table 1: Composition of the prepared frit

Material	wt%
Urdhuma flint SiO_2	30
Talc $3MgO.SiO_2.H_2O$	30
Pota ash K_2CO_3	8
Soda Ash Na_2CO_3	12
Boric Acid $B2O_3.3H_2O$	20

Table 2: Foaming agents and Base Glass percentages in the final mix.

Material*	wt%
Carbon fine powder	6
Sugar fine powder	10
Sodium Silicate penta-hydrate $D=1.5 g/cm^3$	30
Base Glass	54

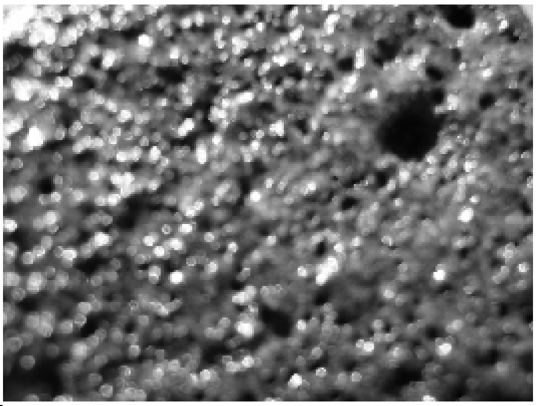
*10ml of tap water is added to facilitate mixing to homogeneous paste.

Table 3: Physical properties of the prepared foamed glass.

Property	Value
Bulk density	1.07 g/cm^3
Porosity	32.9%
Water absorption	30.8%

Table 4: Mechanical properties of the prepared foamed glass.

Property	Value
Impact strength	0.137 J/cm^2
Compressive strength	749.4 MPa



a-

-b-

Figure (1) a: the outer surface of the foamed glass, b: its surface after saw cut.

-a-

-b-

Figure (2) a: the prepared foamed glass, b: foamed glass as seen in ref[1].